GERAGHTY & MILLER, INC.
Environmental Services

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March 14, 1996

Mr. William Harmon
Michigan Department of Environmental Quality
Environmental Response Division/Superfund Section
301 S. Capitol
Lansing, MI 48933

Re: Information For Use in Revising the Feasibility Study Report
North Bronson Industrial Area Superfund Site; Bronson, Michigan

Dear Mr. Harmon:

On behalf of the North Bronson Industrial Site Potentially Responsible Party Group (PRP Group), Geraghty & Miller, Inc. is submitting three copies each of the following documents prepared for the North Bronson Industrial Area Site (the "North Bronson Site").

- Description and Evaluation of Alternate Groundwater Remedies
- Recommended Revised Remedial Action Objectives Based on the Part 201 Amendments
- Assessment of Potential Surface Water Impacts Associated With Vented Groundwater

It is the understanding of the PRP Group that the Michigan Department of Environmental Quality (MDEQ), in cooperation with the United States Environmental Protection Agency (USEPA), is revising the Final Feasibility Study (FS) Report for the North Bronson Industrial Area Site. It is further understood that these revisions are being made to address the recently enacted Amendments to Part 201 of the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451, as well as to address other aspects of the FS Report. The PRP Group encourages these revisions and believes there are several aspects of the FS Report that deserve close attention during the revision process. These aspects include the proper incorporation of the Part 201 Amendments as an applicable or relevant and appropriate requirement (ARAR) for the North Bronson Site, the assessment of potentially viable and cost-effective groundwater remedies, and the assessment of potential surface water impacts to County Drain #30 and Swan Creek associated with vented groundwater. The enclosed documents are being submitted to provide information to the MDEQ and USEPA for addressing these issues in revising the FS Report for the North Bronson Site.

The PRP Group appreciates the opportunity to provide this information to the MDEQ and USEPA for use in revising the FS Report. In addition, the PRP Group looks forward to assisting

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the MDEQ and the USEPA in addressing other relevant site issues in an effort to ensure that the most appropriate remedy is selected for the North Bronson Site.

Should you have any questions or comments regarding the submitted documents, please contact the undersigned at (414) 277-6213.

Sincerely,

Michael S. Maierle, P.E.
Senior Engineer/Environmental

cc: Rosita Clarke-Moreno, USEPA Region V
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DESCRIPTION AND EVALUATION
OF ALTERNATE GROUNDWATER REMEDIES

SUPPLEMENT TO THE FEASIBILITY STUDY
FOR THE
NORTH BRONSON INDUSTRIAL AREA SITE
BRONSON, MICHIGAN

March 14, 1996

On behalf of the North Bronson Industrial Site Potentially Responsible Party Group (PRP Group), Geraghty & Miller, Inc. has prepared this Description and Evaluation of Alternate Groundwater Remedies for the North Bronson Industrial Area Site in Bronson, Michigan. This document is intended to provide information to be used in supplementing the Final Feasibility Study (FS) Report (Montgomery Watson, Inc. 1995) for the North Bronson Industrial Area Site. It is the understanding of the PRP Group that the Final FS Report is to be revised to address the recently enacted Amendments to Part 201 of the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451, as well as to address other aspects of the Final FS Report. One aspect of the FS Report that the PRP Group believes deserves attention is the assessment of potential groundwater remedies. The groundwater remedies evaluated in the FS Report for the Western Lagoon area groundwater and the Eastern Lagoon area groundwater incorporate only conventional groundwater pumping and on-site ex-situ treatment technologies. Other potentially cost-effective groundwater remedies that incorporate in-situ groundwater treatment technologies were not assessed in the FS Report.

The information on alternate groundwater remedies presented herein is applicable for incorporation into the revised/amended FS Report if it is determined that groundwater remediation is required for the Eastern and Western Lagoon areas. Based on the provisions of the Part 201 Amendments that allow for natural groundwater venting under certain circumstances (Section 20120a(15)), groundwater remediation for the groundwater that naturally vents to County Drain #30 in the areas of the Eastern and Western Lagoons may not be necessary. If it can be technically demonstrated that the venting of groundwater into County Drain #30 from the Eastern and Western lagoon areas would not cause adverse impacts to surface water quality then groundwater remediation would not be required. It is the understanding of the PRP Group that a technical assessment of potential impacts to surface water quality has not yet been completed by the Michigan Department of Environmental Quality (MDEQ)[1]. Thus, it has yet to be determined whether any groundwater remediation is necessary for the Eastern and Western Lagoon areas. However, if it can be established that groundwater remediation is required for the groundwater that naturally vents to County Drain #30 from the areas encompassing the Western and Eastern

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[1] To assist the MDEQ in this endeavor, the PRP Group has issued a separate submittal presenting an assessment of potential surface water quality impacts associated with the venting of groundwater to County Drain #30.

Lagoons, the PRP Group recommends that other in-situ groundwater remedial alternatives be considered in the revised/amended FS Report, as described herein.

If active groundwater remediation is deemed necessary, the revised/amended FS Report should also provide consideration of **direct discharge of collected groundwater to the Bronson Publicly Owned Treatment Works (POTW)**, in addition to the consideration of alternate in-situ groundwater remedies. The groundwater remedial alternatives developed and evaluated in the Final FS Report incorporate on-site groundwater treatment systems, which would be very expensive to install and operate. **Based on the 1994 upgrades to the Bronson POTW, direct discharge to the POTW may be a viable discharge option**. Thus, in addition to alternate in-situ groundwater remedies, the PRP Group recommends consideration of groundwater collection and direct discharge to the Bronson POTW in the revised/amended FS Report if it is determined that active groundwater remediation is necessary.

To assist the MDEQ in the potential incorporation of these items into the revised/amended FS Report, descriptions and evaluations of alternate groundwater remedies have been prepared which incorporate the following technologies:

- In-situ vegetative remediation
- In-situ metals precipitation
- Groundwater recovery and direct discharge to the POTW

Consistent with the format of the FS Report, individual sections are presented for technology screening and detailed analysis of alternatives. The PRP Group requests that this information be considered by the MDEQ in revising/amending the FS Report if it is determined that groundwater remediation is deemed necessary for the Eastern and Western Lagoon areas.

I. SCREENING OF ALTERNATE GROUNDWATER TECHNOLOGIES

The following alternate groundwater remediation technologies have been screened on the general basis of **effectiveness, implementability and cost relative to** site conditions and the current remedial response objectives.

A. IN-SITU VEGETATIVE REMEDIATION

In-situ vegetative remediation (phytoremediation) involves the use of deep rooted vegetation to remediate soils and groundwater. The development of deep root systems into the soil permits the uptake of contaminated groundwater and active removal and/or enhanced degradation of a wide variety of hydrocarbons, chlorinated organics, pesticides, and inorganic contaminants such as heavy metals and nitrates. In general, organic contaminants are metabolized whereas heavy metals bioaccumulate in the plant tissue. Depending on the plant species utilized, vegetative remediation can be effective in controlling and remediating groundwater to depths of 30 feet below grade (Gatliff 1994). Because this remediation technique can be effective for both organic and inorganic contaminants and because the depth of soil and groundwater contamination underlying the Western and Eastern Lagoons is relatively shallow, vegetative remediation shows high potential as an effective remediation technique for the North Bronson Industrial Area site. Although vegetative remediation is a new and innovative technology, it is being utilized on at least three National Priorities List (NPL) (i.e., Superfund) sites (Whitewood Creek Site in South Dakota, Galena Site in Kansas, and the Tibbetts Road Site in New Hampshire) as well as at over 50 other non-NPL remediation sites across the country.

Deep rooted plants can remediate organic contaminants via three main mechanisms: 1) direct uptake through the roots and subsequent volatilization, metabolic degradation, mineralization or accumulation into plant tissue, 2) degradation in the surrounding soil by enzymes and exudates released by the plants, and 3) mineralization in the rhizosphere (i.e., the root-soil interface) (Schnoor et. al. 1995). Conversely, deep rooted plants remediate inorganic contaminants via four main mechanisms: 1) uptake into the vegetation's root system by plant transpiration, 2) adsorption onto the vegetation's root system, 3) bonding to exchange sites on inorganic soil constituents, and 4) adsorption to insoluble organic matter (Pierzynski et. al. 1994). A number of different tree species (e.g., willows, poplars, cottonwoods) have been shown to be effective in phtyoremediation applications. The water uptake of these plant species can range from 50 to 350 gallons per day for a cottonwood in relatively humid environments to upwards of 5,000 gallons per day for a large mature willow (Gatliff 1994).

Given the site topography, site use, and shallow depth to groundwater, vegetative remediation could be easily implemented at both the Eastern Lagoon and the Western Lagoon areas. In addition, this remediation technique is very cost-effective in comparison to conventional groundwater pump and treat technologies. Based on its effectiveness for remediating both organic and inorganic contaminants, low cost and ease of implementation, vegetative remediation should be retained as an applicable in-situ soil and groundwater remediation technique for the North Bronson Industrial Area site.

B. IN-SITU METALS PRECIPITATION

In-situ metals precipitation involves modification of the subsurface geochemical conditions to promote precipitation of dissolved heavy metals within an aquifer. Recent advances have been made in creating in-situ reactive zones for the precipitation of dissolved metals present within groundwater. In-situ reactive zones are defined as zones in which microbial or chemical redox reactions can be achieved by injecting suitable innocuous reagents within the impacted portion of the aquifer. Appropriate redox reactions can be achieved which lead to the subsequent precipitation of the dissolved metals. The precipitates are then retained (i.e., filtered out) by the soil matrix within the aquifer. Various in-situ precipitation techniques can be applied to achieve precipitation of the following dissolved heavy metal ions: hexavalent chromium, lead, mercury, nickel, cadmium, silver, zinc, and arsenic.

A recently developed technique for creating an in-situ reactive zone involves the periodic injection of a innocuous carbohydrate source (e.g., dilute molasses) into an aquifer to develop strong reducing condition (Suthersan et. al. 1995). The carbohydrates are readily degraded by the indigenous heterotrophic microorganisms present in the aquifer. This metabolic degradation process utilizes all of the dissolved oxygen present in the groundwater and, thus, causes strong reducing conditions to develop. The reducing conditions cause oxidized metallic ions to be converted to reduced forms, which are generally less toxic and far less soluble than the more oxidized forms (e.g., hexavalent chromium [Cr^{+6}] is reduced to trivalent chromium [Cr^{+3}]). The reducing conditions also promote the reduction of sulfate to sulfide, which is beneficial because at near neutral pH levels some metals can only precipitate out as a metallic sulfide. Depending on the specific metals involved and the redox reactions which are induced, the dissolved metals can be precipitated out of solution as either a metallic hydroxide precipitate (e.g., chromium hydroxide) or as a metallic sulfide precipitate (cadmium sulfide). The precipitates are then adsorbed onto the soil particles (i.e., filtered-out) in the aquifer. These precipitates will generally remain in the solid form, and be retained within the soil particles of the aquifer, unless there is a subsequent significant pH shift in the groundwater, which is highly unlikely.

In-situ metals precipitation could be used to address the metals within the groundwater underlying the Western and Eastern lagoon areas. Implementation of in-situ metals precipitation could be accomplished through the creation of reactive zones employing a series of injection wells or by the use of permeable reactive trenches installed between the former lagoons and County Drain #30. The capital and long-term operation and maintenance costs associated with this technology are relatively low. If groundwater remediation is required for addressing dissolved heavy metals, in-situ metals precipitation should be retained for further consideration. This technology is not effective, however, in treating organic contaminants. Thus, this technology would only be applicable if it were determined that groundwater remediation for dissolved heavy metals, but not for organic contaminants, is necessary to protect surface water quality in County Drain #30 and Swan Creek.

C. GROUNDWATER RECOVERY AND DIRECT DISCHARGE TO THE POTW

Groundwater recovery could be achieved through the use of groundwater extraction wells or a subsurface collection drain. Given the hydrogeologic conditions associated with this site, a passive subsurface collection drain system positioned along the southern edge of County Drain #30 would likely provide the most cost-effective method of collecting potentially impacted groundwater that would otherwise vent into County Drain #30. A potentially viable option for treatment and discharge of the collected groundwater would be to convey the water to the Bronson POTW, which is located immediately adjacent to the Western Lagoon area. To allow for direct discharge of the recovered groundwater to the Bronson POTW, the concentrations of constituents in the recovered groundwater would have to be below the applicable pretreatment standards established by the POTW. In addition, the POTW must have adequate hydraulic capacity to handle the additional flow from the groundwater collection system.

The Bronson POTW was upgraded in 1994. It currently operates at an average flow rate of approximately 200 gallons per minute (gpm), which is significantly less than its current maximum design rate of 560 gpm. Because it has an average excess treatment capacity of over 300 gpm, the Bronson POTW could potentially be used to treat the groundwater that may need to be recovered from the Eastern and Western Lagoon areas. To allow for this discharge arrangement, the discharge of recovered groundwater would have to comply with specific pretreatment standards and hydraulic limits that may be established by the Bronson POTW. If groundwater collection is deemed necessary at the Eastern and Western Lagoon areas, groundwater collection and discharge to the Bronson POTW should be retained for further consideration.

II. DETAILED ANALYSIS OF ALTERNATE GROUNDWATER REMEDIES

The three alternate groundwater technologies described above have been incorporated into alternate groundwater remedies, which should be considered in the revised/amended FS Report if it can be technically justified that groundwater remediation is required for the groundwater that naturally vents to County Drain #30. A description and analysis of each of the three alternate groundwater remedies are presented below. Consistent with the alternatives analysis presented in the FS Report and the requirements of the National Contingency Plan (NCP) (40 CFR 300, Subpart E, Section 300.430), the analysis of each alternate groundwater remedy includes an assessment against the following nine evaluation criteria:

- Overall protection of human health and the environment.
- Compliance with applicable or relevant and appropriate requirements (ARARs).
- Long-term effectiveness and permanence.
- Reduction of toxicity, mobility, or volume through treatment.
- Short-term effectiveness.
- Implementability.
- Cost.
- State acceptance.
- Community acceptance.

Note that the analyses of the alternate groundwater remedies only address groundwater issues. Potential environmental concerns associated with surface and subsurface soils would need to be addressed by other remedial control measures. Each of the three alternate groundwater remedies may need to be combined with other remedial control measures (e.g., institutional controls, site fencing, soil cover, etc.) to effect an overall remedy for the Eastern and Western Lagoon areas that is protective of human health and the environment.

A. IN-SITU VEGETATIVE REMEDIATION ALTERNATIVE

The following sections present a description and an analysis of the in-situ vegetative remediation alternative.

1. Description of In-Situ Vegetative Remediation Alternative

The in-situ vegetative remediation alternative would involve planting deep-rooted trees within the area of the former Eastern and Western Lagoons and within the areas between County Drain #30 and the former lagoons. The main function of the trees would be to promote degradation or transpiration-induced volatilization of organic contaminants and bioaccumulation or adsorption of inorganic contaminants. The trees would also minimize downward infiltration through the vadose zone into the underlying groundwater and limit migration of potentially impacted groundwater by the "pumping effect" of the trees. It is assumed that [redacted] would be used because they are perennial, deep rooted, long living trees. When used for phytoremediation applications, the poplars are generally planted at a density of approximately 100 trees per acre [redacted]. For cost estimating purposes, it has been assumed that a total of seven acres of land would be planted under this alternative (approximately two acres for the Eastern Lagoon area and five acres for the Western Lagoon area). The planting arrangement would consist of multiple rows of trees spaced on approximately 20 feet centers. The first row would be positioned adjacent and parallel to County Drain #30, with subsequent parallel rows extending to the southern extent of the respective lagoon areas. This multiple-row tree planting arrangement would likely be necessary to provide coverage over the full extent of groundwater movement that could occur between growing seasons. The extent of tree coverage relative to groundwater movement through the lagoon areas would need to be thoroughly assessed as part of the remedial design because water uptake through the root system only occurs during the growing season.

Prior to implementation, an agronomic assessment would need to be performed. The purpose of the agronomic assessment would be to determine the physical and chemical soil characteristics relating to vegetative growth such that the appropriate tree species and planting density could be established. Prior to tree planting, the former Eastern and Western Lagoon areas would need to be regraded (i.e., the existing berms would be leveled). Depending on the characteristics of the existing soils, additional nutrient rich soil may need to be imported from off-site sources. A maintenance program for tree watering and fertilizing, and potential replacement of trees that do not survive the first growing season, would need to be implemented following planting activities.

2. ***Detailed Analysis of In-Situ Vegetative Remediation Alternative***

The in-situ vegetation remediation alternative has been assessed against the nine evaluation criteria specified in the NCP. This assessment is summarized below.

Overall Protection of Human Health and the Environment

The in-situ vegetation remediation alternative would provide a reasonably high degree of overall protection of human health and the environment. As the root structures of the trees begin to grow downward and outward, the trees would promote degradation or transpiration-induced volatilization of organic contaminants and bioaccumulation or adsorption of inorganic contaminants. In addition, the trees would minimize downward infiltration through the vadose zone into the underlying groundwater and limit migration of potentially impacted groundwater by the "pumping effect" of the trees. Thus, this alternative would serve to reduce the mass flux of both organic and inorganic contaminants into County Drain #30 currently associated with the groundwater that is vented from the Eastern and Western lagoon areas.

Compliance with ARARs

Because the groundwater from the lagoon areas vents into County Drain #30 and there are no known users of this groundwater, the chemical-specific ARARs that apply to the groundwater in the Eastern and Western Lagoon areas are groundwater standards that are protective of surface water. Thus, the applicable chemical-specific ARARs are either the generic groundwater/surface water interface (GSI) values established by the MDEQ or site-specific values that are established based on the use and water quality of the receiving surface water. To date, site-specific groundwater standards that are protective of surface water quality in County Drain #30 and Swan Creek have not been established. Regardless of whether generic GSI values or site-specific groundwater standards that are protective of surface water are applied to this site, it is expected that over a period of several years the in-situ vegetation remedy would effectively treat and/or contain the impacted groundwater such that chemical-specific ARARs would be met at the point of compliance along County Drain #30.

Long-Term Effectiveness and Permanence

The in-situ vegetation remediation alternative would provide a reasonably high degree of long-term effectiveness and permanence. By promoting degradation or transpiration-induced volatilization of organic contaminants and bioaccumulation or adsorption of inorganic contaminants, the in-situ vegetation remedy would reduce or eliminate contaminant migration into County Drain #30. Thus, the current main contaminant migration pathway would be reasonably controlled. A potential drawback to the in-situ vegetation remedy is that the inorganic contaminants and a portion of the organic contaminants would be bioaccumulated within the plant tissue or adsorbed within the root system. Thus, land use would likely always need to be restricted because these constituents would remain in place.

Reduction of Toxicity, Mobility or Volume through Treatment

Over time, the in-situ vegetation remedy would serve to reduce the mass and toxicity of organic contaminants and reduce the mobility of inorganic contaminants that are present in the groundwater underlying the Eastern and Western Lagoon areas.

Short-Term Effectiveness

The in-situ vegetation remedy would provide a relatively low degree of short-term effectiveness because it would take a year or two for the root systems to take hold and effect a relatively large area.

Implementability

The in-situ vegetation remedy could be readily implemented. The required agronomic assessment and site regrading activities could be conducted over a relatively short time frame. The only scheduling constraint is that the trees should be planted early during the growing season.

Costs

The total capital cost for implementing the in-situ vegetation remedy is estimated to be [redacted] and the annual operation and maintenance (O&M) cost is estimated to [redacted]. Assuming a 30 year design life, the total present worth for the in-situ vegetation remedy is estimated to [redacted]. An itemized breakdown of the costs for this remedy is presented in Table 1.

State Acceptance

MDEQ's position on an in-situ vegetation groundwater remedy for the Eastern and Western Lagoon areas is not known at this time. However, the use of in-situ vegetative remediation would be consistent with Section 20118(12) of the amendments to Part 201 of the Michigan Natural Resources and Environmental Protection Act, which encourages the use of innovative cleanup technologies.

Community Acceptance

The local community's position on an in-situ vegetation remedy is not known at this time.

B. IN-SITU METALS PRECIPITATION REMEDIATION ALTERNATIVE

The following sections present a description and an analysis of the in-situ metals precipitation remediation alternative.

1. Description of In-Situ Metals Precipitation Remediation Alternative

The in-situ metals precipitation remediation alternative would involve creating in-situ reaction zones for modifying the subsurface geochemical conditions for promoting the precipitation of dissolved heavy metals within the aquifer. As stated previously, the in-situ metals precipitation process is not effective in treating organic contaminants. Thus, this alternate groundwater remedy would only be applicable if it was determined that groundwater remediation for dissolved heavy metals, but not for organic contaminants, is necessary to protect surface water quality in County Drain #30 and Swan Creek. The in-situ metals precipitation remediation alternative would require the installation of reaction zone trenches positioned between County Drain #30 and the respective Eastern and Western Lagoons. These trenches would be approximately 3 feet wide by approximately 30 feet deep (the assumed depth to the confining layer). It is assumed that the trench for the Eastern Lagoon area would be approximately 400 feet long and the trench for the Western Lagoon area would be approximately 800 feet long. The trenches would be filled with coarse aggregate and the trench spoils could be reconsolidated into the lagoons prior to placement of a soil cover across the lagoons. Reducing conditions would be developed within the reaction trenches through the periodic addition of a dilute carbohydrate source, such as molasses. A series of injection well clusters would be installed within the trenches.

Groundwater emanating from the lagoons areas would pass slowly through the two reaction zones and would be subject to strong reducing conditions that would continually exist within the reaction zones. Under the strong reducing conditions, the sulfate present in the groundwater along with the sulfate present in the dilute molasses solution would be reduced to sulfide. The sulfide would then be available for the formation of metallic sulfide precipitates (e.g., cadmium sulfide, lead sulfide). In addition, any hexavalent chromium present in the groundwater would be reduced to trivalent chromium which would then precipitate out as a chromium hydroxide precipitate.

Although this in-situ metals precipitation process has been shown to be very effective in certain applications (Suthersan et. al. 1995), it may not be completely effective for the Eastern and Western Lagoon areas. Certain metal complexes (e.g., cadmium cyanide complexes) are very stable and thus are difficult to precipitate out of solution. The presence of complexing agents in the groundwater would thus serve to limit the effectiveness of the process. In addition, due to the addition of a carbohydrate source into the groundwater, the levels of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) would increase. The carbohydrates are generally fully degraded over time as the groundwater reverts back to natural conditions following passage through the reaction zone. However, because the reaction trenches would be positioned in close proximity to County Drain #30, the residual carbohydrates might not fully degrade prior to the groundwater being vented into County Drain #30. Thus, the groundwater that would subsequently vent to County Drain #30 may have elevated BOD and COD levels. For these reasons, a pilot study program would be necessary to establish the effectiveness of this process for use at the Eastern and Western Lagoon areas. Full-scale implementation of the in-situ metals precipitation process would be viable only if the results of the pilot study program indicate that the process is fully effective in achieving significant precipitation of the dissolved heavy metals and that the resultant vented groundwater to County Drain #30 would not cause adverse surface water quality impacts.

2. *Detailed Analysis of In-Situ Metals Precipitation Remediation Alternative*

The in-situ metals precipitation remediation alternative has been assessed against the nine evaluation criteria specified in the NCP. This assessment is summarized below.

Overall Protection of Human Health and the Environment

The in-situ metals precipitation remediation alternative would likely provide a high degree of overall protection of human health and the environment. This assumes, however, that the process could achieve significant precipitation of the dissolved heavy metals within the reaction zone. As stated above, a pilot study would need to be conducted to establish the degree of effectiveness of this process. The main benefit of the process would be to prevent the migration of dissolved heavy metals that may otherwise discharge into County Drain #30. The process, however, would not be effective in preventing organic contaminants from being discharged into County Drain #30.

Compliance with ARARs

Although the effectiveness of the process would have to be confirmed through a pilot study program, it is expected that the in-situ metals precipitation process would promote a significant degree of metals precipitation such that site-specific groundwater standards that are protective of surface water quality in County Drain #30 and Swan Creek could be met. It is uncertain, however, if generic GSI values could be met by the in-situ metals precipitation process. The results of a pilot study program would have to be assessed to better determine whether the in-situ metals precipitation process could meet generic GSI values.

Long-Term Effectiveness and Permanence

Based on the assumption that the process could achieve significant precipitation of the dissolved heavy metals within the reaction zone, the in-situ metals precipitation remediation alternative would provide a reasonably high degree of long-term effectiveness and permanence. Again, this assumption would have to be confirmed based on the results of a pilot study program. A key consideration in assessing the long-term permanence for this remedy is the long-term stability of the precipitated metals. The process would have a low degree of long-term permanence if the precipitated metals resolubilize over time. However, almost all metallic sulfide precipitates are very stable and insoluble over a wide pH range. Thus, once precipitated, the metals should remain in the solid phase bound within the aquifer. Thus, if the process is effective in initially achieving metals precipitation, the in-situ metals precipitation remedy would provide a relatively high degree of long-term effectiveness and permanence.

Reduction of Toxicity, Mobility or Volume through Treatment

The in-situ metals precipitation remedy would function to reduce the mobility of the dissolved heavy metals present in the groundwater by promoting their precipitation within the aquifer. In addition, the process would also serve to reduce the toxicity of certain metals by reducing their oxidation state (e.g., promoting the reduction of hexavalent chromium to trivalent chromium).

Short-Term Effectiveness

The in-situ metals precipitation remedy would provide a moderate degree of short-term effectiveness. Because the process would rely on natural groundwater movement through the reaction zones, it would likely take several months to a year before there would be a significant reduction in the concentrations of dissolved metals in the groundwater that vents to County Drain #30.

Implementability

Although implementation of the in-situ metals precipitation remedy could be readily accomplished, a pilot study program would first have to be conducted to confirm the effectiveness of the process. If the results of the pilot study program confirm that the process would be effective in achieving significant precipitation of dissolved heavy metals, it is expected that the in-situ metals precipitation remedy could be implemented without any technical or administrative difficulties.

Costs

The total capital cost for implementing the in-situ metals precipitation remedy is estimated to be $280,700 and the annual O&M cost is estimated to be $83,400. Assuming a 30 year design life, the total present worth for the in-situ metals precipitation remedy is estimated to be $1,562,700. An itemized breakdown of the costs for this remedy is presented in Table 2.

State Acceptance

MDEQ's position on an in-situ metals precipitation remedy for the Eastern and Western Lagoon areas is not known at this time. However, the use of in-situ metals precipitation remediation would be consistent with Section 20118(12) of the amendments to Part 201 of the Michigan Natural Resources and Environmental Protection Act, which encourages the use of innovative cleanup technologies.

Community Acceptance

The local community's position on an in-situ metals precipitation remedy is not known at this time.

A. GROUNDWATER RECOVERY AND POTW DISCHARGE REMEDIATION ALTERNATIVE

The following sections present a description and an analysis of the groundwater recovery and POTW discharge remediation alternative.

1. Description of Groundwater Recovery and POTW Discharge Remediation Alternative

The groundwater recovery and POTW discharge remediation alternative would involve collecting groundwater from both the Eastern and Western Lagoon areas and conveying the collected groundwater to the Bronson POTW for treatment. The main function of this groundwater remedy would be to collect the groundwater that currently vents to County Drain #30 from the Eastern and Western Lagoon areas and thereby minimize or eliminate organic and inorganic contaminant releases into County Drain #30. The most simplistic and cost-effective means for groundwater collection would be through the use of subsurface collection drains installed parallel to County Drain #30 along the northern edge of both the Eastern Lagoon area and the Western Lagoon area. It is assumed that the drain invert would be placed approximately 20 feet below grade and the drain lengths would be approximately 400 feet and 800 feet for the Eastern and Western Lagoon areas, respectively. Because of this relatively shallow depth, the drain could be readily installed using a drain trencher that performs trenching, drain pipe placement, and gravel drainage envelop installation simultaneously.

Because the purpose of the drains would be to collect groundwater that would otherwise vent into County Drain #30, the drains could operate as passive collection drains. This would minimize the flow that would need to be collected. Based on the hydrogeologic information presented in the Remedial Investigation (RI) Report (Warzyn 1993), it is estimated on a preliminary basis that the combined recovery rate from the drains would be on the order of 10 to 30 gpm. The drains would include multiple collection sumps which would be outfitted with sump pumps for pumping the water out of the drains.

Under this alternative, it has been assumed, based on the relatively low levels of constituents measured in the groundwater, that the collected groundwater could be directly discharged to the Bronson POTW without the need for pretreatment (i.e., the collected groundwater would not exceed the pretreatment standards which would be established by the Bronson POTW). The Bronson POTW does not currently have generic pretreatment standards and, thus, would have to assign pretreatment standards specific to this discharge. A more thorough assessment of the necessity for pretreatment, as well as an assessment of the available hydraulic and treatment capacity of the POTW, would need to be performed during the preliminary remedial design should this alternative be implemented.

2. *Detailed Analysis of Groundwater Recovery and POTW Discharge Remediation Alternative*

The groundwater recovery and POTW discharge remediation alternative has been assessed against the nine evaluation criteria specified in the NCP. This assessment is summarized below.

Overall Protection of Human Health and the Environment

The groundwater recovery and POTW discharge remediation alternative would provide a very high degree of overall protection of human health and the environment. The subsurface drains would be very effective in collecting groundwater that would otherwise vent into County Drain #30. Thus, this alternative would serve to minimize or eliminate the mass flux of organic and inorganic contaminants associated with the groundwater from the Eastern and Western Lagoon areas that currently vents into County Drain #30. Utilizing a portion of the available treatment capacity of the Bronson POTW would be a very effective means for treating the recovered groundwater.

Compliance with ARARs

By collecting the groundwater from the Eastern and Western Lagoon areas that would otherwise vent into County Drain #30, the groundwater recovery and POTW discharge option would comply with either the generic GSI values or site-specific groundwater standards that are protective of surface water. It is assumed that the collected groundwater would meet the POTW pretreatment standards without the need for on-site treatment. However, a more thorough assessment regarding the potential need for pretreatment would need to be performed as part of the remedial design activities.

Long-Term Effectiveness and Permanence

The groundwater recovery and POTW discharge alternative would provide a very high degree of long-term effectiveness and permanence. If properly maintained, the subsurface drains would likely provide proper hydraulic capture of the groundwater for decades without the need for replacement.

Reduction of Toxicity, Mobility or Volume through Treatment

By utilizing the treatment capacity of the Bronson POTW, the groundwater recovery and POTW discharge option would provide for treatment of the collected groundwater.

Short-Term Effectiveness

The groundwater recovery and POTW discharge alternative would provide a high degree of short term effectiveness because the subsurface drain would cutoff groundwater flow to County Drain #30 upon system startup.

Implementability

The groundwater recovery and POTW discharge alternative could be readily implemented without excessive technical or administrative difficulties.

Costs

The total capital cost for implementing the groundwater recovery and POTW discharge alternative is estimated to be $314,300 and the annual O&M cost is estimated to be $78,000. Assuming a 30 year design life, the total present worth for the groundwater recovery and POTW discharge alternative is estimated to be $1,513,300. An itemized breakdown of the costs for this remedy is presented in Table 3. Note that if pretreatment of the collected groundwater would be required prior to discharge to the POTW, then the costs for this remedy could increase significantly.

State Acceptance

MDEQ's position on a groundwater recovery and POTW discharge remedy for the Eastern and Western Lagoon areas is not known at this time.

Community Acceptance

The local community's position on a groundwater recovery and POTW discharge remedy is not known at this time.

REFERENCES

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**TABLE 1: ESTIMATED COSTS FOR IN-SITU VEGITATION REMEDY
NORTH BRONSON INDUSTRIAL AREA SITE; BRONSON, MICHIGAN**

CAPITAL COSTS	QUANTITY	UNIT	UNIT COST	TOTAL COST
Mobilization/demobilization	1	LS	$10,000	$10,000
Surveying	1	LS	$2,000	$2,000
Health and safety provisions	1	LS	$2,000	$2,000
Land acquisition	1	LS	$10,000	$10,000
Tree planting	7	acre	$15,000	$105,000
CONSTRUCTION COST SUBTOTAL				**$129,000**
Scope Contingency (10%)				$12,900
Agronomic Assessment/Design				$40,000
Construction Management				$10,000
TOTAL CAPITAL COST				**$191,900**

ANNUAL O & M COSTS	YEARLY COST
Misc. tree replacement	$7,000
Quarterly groundwater monitoring	$24,000
Project management/reporting	$12,000
ANNUAL O & M COST	**$43,000**

TOTAL PRESENT WORTH	**$852,900**
over 30 years, 5% rate	

TABLE 2: ESTIMATED COSTS FOR IN-SITU METALS PRECIPITATION REMEDY
NORTH BRONSON INDUSTRIAL AREA SITE; BRONSON, MICHIGAN

CAPITAL COSTS	QUANTITY	UNIT	UNIT COST	TOTAL COST
Mobilization/demobilization	1	LS	$15,000	$15,000
Surveying	1	LS	$2,000	$2,000
Health and safety provisions	1	LS	$2,000	$2,000
Decon facilities	1	LS	$4,000	$4,000
Tench excavation	4,000	cu yd	$18.00	$72,000
Reconsolidation of excavated soils	2,000	cu yd	$6.00	$12,000
Placement of filter fabric	72,000	sq ft	$0.40	$28,800
Gravel backfill	2,000	cu yd	$18.00	$36,000
Injection well points	2,880	lin ft	$8.00	$23,000
Portable solution feed system	1	LS	$8,000	$8,000
Additional monitoring wells	8	well	$2,000	$16,000
CONSTRUCTION COST SUBTOTAL				**$218,800**
Scope Contingency (10%)				$21,900
Engineering Design				$25,000
Construction Management				$15,000
TOTAL CAPITAL COST				**$280,700**

ANNUAL O & M COSTS	YEARLY COST
Operating Labor	$24,000
Carbohydrate feed solution	$2,400
Routine maintenance	$5,000
Quarterly system/groundwater monitoring	$32,000
Project management/reporting	$20,000
ANNUAL O & M COST	**$83,400**

TOTAL PRESENT WORTH over 30 years, 5% rate	**$1,562,700**

TABLE 3: ESTIMATED COSTS FOR GOUNDWATER RECOVERY/POTW DISCHARGE REMEDY NORTH BRONSON INDUSTRIAL AREA SITE; BRONSON, MICHIGAN

CAPITAL COSTS	QUANTITY	UNIT	UNIT COST	TOTAL COST
Mobilization/demobilization	1	LS	$25,000	$25,000
Surveying	1	LS	$2,000	$2,000
Health and safety provisions	1	LS	$2,000	$2,000
Decon facilities	1	LS	$4,000	$4,000
Subsurface drain installation	1,200	ln ft	$110.00	$132,000
Reconsolidation of excavated soils	440	cu yd	$6.00	$2,600
Collection sumps/pumps	6	each	$4,000	$24,000
Valves/instrumentation	1	LS	$10,000	$10,000
Electrical hook-up/controls	1	LS	$25,000	$25,000
CONSTRUCTION COST SUBTOTAL				**$226,600**
Scope Contingency (10%)				$22,700
Engineering Design				$40,000
Construction Management				$25,000
TOTAL CAPITAL COST				**$314,300**

ANNUAL O & M COSTS	YEARLY COST
Operating Labor	$12,000
Electricity	$8,000
Routine maintenance	$5,000
Sewer user charge	$9,000
Quarterly system/groundwater monitoring	$24,000
Project management/reporting	$20,000
ANNUAL O & M COST	**$78,000**

TOTAL PRESENT WORTH over 30 years, 5% rate	**$1,513,300**

RECOMMENDED REVISED REMEDIAL ACTION OBJECTIVES
BASED ON THE PART 201 AMENDMENTS

SUPPLEMENT TO THE FEASIBILITY STUDY
FOR THE
NORTH BRONSON INDUSTRIAL AREA SITE
BRONSON, MICHIGAN

March 14, 1996

On behalf of the North Bronson Industrial Site Potentially Responsible Party Group (PRP Group), Geraghty & Miller, Inc. submits this recommendation to revise the remedial response objectives based on the amendments to Part 201 of the Michigan Natural Resources and Environmental Protection Act (the "Part 201 Amendments), 1994 PA 451, for the North Bronson Industrial Area Site in Bronson, Michigan. The current remedial action objectives (RAOs) presented in Section 2.2 of the Final Feasibility Study (FS) Report (Montgomery Watson, Inc. 1995) are based on cleanup criteria originally established under the Michigan Environmental Response Act (MERA), formerly known as Michigan Act 307, which was identified as an applicable or relevant and appropriate requirement (ARAR) in the FS. However, the cleanup criteria and remedial response requirements of MERA were superseded by the Part 201 Amendments. The Part 201 Amendments significantly modify the cleanup criteria and remedial response requirements that are applicable to the North Bronson Site.

This document is intended as a supplement to the FS Report. It is the understanding of the PRP Group that the Michigan Department of Environmental Quality (MDEQ), in cooperation with the U.S. Environmental Protection Agency (USEPA), is currently revising and/or amending the Final FS Report to incorporate the Part 201 Amendments, which became effective June 5, 1995, as an ARAR for the North Bronson Site. This document provides assistance to the MDEQ in developing appropriate RAOs for the North Bronson Site which are consistent with the cleanup criteria and remedial response requirements established under the Part 201 Amendments.

Recommended revised RAOs have been developed based on applying the cleanup criteria and remedial response requirements established under the Part 201 Amendments. These recommended revised RAOs are presented below for the media addressed in the FS Report for the North Bronson Site. A number of the revised RAOs are based on utilizing site-specific risk-based criteria, as allowed under Section 20120a(2) and (4) of Part 201. To assist the MDEQ in establishing these site-specific risk-based criteria, the PRP Group is preparing a site-specific risk assessment based on applicable MDEQ and USEPA guidance. Numerical values for the site-specific risk-based RAOs cannot be established until the site-specific risk assessment is completed.

I. RECOMMENDED REVISED REMEDIAL ACTION OBJECTIVES

The following recommended revised RAOs are to be used to determine what degree of remediation, if any, is required for the media that comprise the portion of the North Bronson Industrial Area Site addressed in the FS Report (i.e., Eastern Lagoon area, Western Lagoon area, and County Drain #30). The media-specific RAOs presented below follow the same order and format as the current RAOs presented in Section 2.2 of the FS Report. The recommended revised RAOs listed below are based on chemical-specific ARARs and site-specific risk-based criteria, as appropriate.

A. Lagoon Area Soils and Sediments

Because the Eastern and Western Lagoon areas are in an industrial setting and are zoned industrial, the appropriate RAOs are based on exposure scenarios associated with current and future industrial land use.

Recommended Lagoon Soil/Sediment Cleanup Criteria Based on ARARs

The following cleanup criteria apply assuming a site-specific risk-based cleanup for the North Bronson Site.

- Site-specific risk-based direct contact criteria determined based on a site-specific risk assessment.
- Site-specific soil criteria that is protective of groundwater/surface water. These criteria will be established based on fate and transport modeling and/or synthetic leaching tests in accordance with MDEQ Operational Memorandum #14 (MDEQ 1995).

Default Lagoon Soil/Sediment Cleanup Criteria Based on ARARs

The following cleanup criteria apply in the absence of site-specific risk-based criteria for the North Bronson Site.

- Generic industrial direct contact criteria for soil as listed in MDEQ Operational Memorandum #14 (MDEQ 1995).
- Soil criteria that is protective of groundwater/surface water based on using 20 times the appropriate groundwater criterion, 20 times the generic groundwater/surface water interface (GSI) value, leachate test results, or fate and transport modeling in accordance with MDEQ Operational Memorandum #14 (MDEQ 1995), as applicable.

Once the site-specific risk-based cleanup objectives and groundwater criterion that is protective of surface water are established, the lagoon soil/sediment analytical data obtained during the remedial investigation (RI) will need to be compared against the cleanup objectives to determine whether, and to what degree, the lagoon soils and sediments will need to be remediated to meet the following revised RAOs. A similar comparison to the generic industrial cleanup criteria would need to be made in the absence of site-specific risk based criteria for the North Bronson Site.

Recommended Revised RAOs for Lagoon Soils/Sediments

Based on the cleanup criteria listed above, the following recommended revised RAOs are applicable for the lagoon soils and sediment at the North Bronson Site.

- Reduce, treat, contain or otherwise limit exposure to lagoon soils and sediments that contain constituents at levels above the established site-specific risk-based direct contact criteria or the generic industrial direct contact criteria, depending on which criteria is utilized for this site.
- Reduce, treat or contain lagoon soils and sediments located above the water table that contain constituents at levels above the site-specific soil criteria that is protective of groundwater/surface water or 20 times the groundwater criteria or GSI values, as applicable.
- If constituents are left in place at concentrations above the applicable direct contact criteria, prevent exposure to lagoon soils and sediments.

B. Lagoon Area Groundwater

Because the groundwater from the lagoon areas vents into County Drain #30 and because there are no known local users of this groundwater, the appropriate RAOs for the lagoon area groundwater are based on the protection of surface water quality. Section 20120a(15) of Part 201 allows for the use of a mixing zone in quantifying the impact of groundwater to surface water. The Surface Water Quality Division (SWQD) of the MDEQ has designated County Drain #30 and one quarter of the design flow for Swan Creek as a mixing zone (County Drain #30 discharges to Swan Creek) (Kosak, pers. comm. 1996). Thus, the applicable groundwater cleanup objectives would be site-specific groundwater standards that are based on meeting acute water quality criteria within the mixing zone and chronic water quality criteria at the boundary of the mixing zone (Rule 323.1082).

Recommended Groundwater Cleanup Criteria Based on ARARs

The following groundwater cleanup criteria apply:

- Site-specific groundwater standards established at the venting point to County Drain #30 based on meeting the applicable acute water quality criteria within the mixing zone and chronic water quality criteria at the boundary of the mixing zone.

Recommended Revised RAOs for Lagoon Area Groundwater

Based on the cleanup criteria listed above, the following recommended revised RAOs are applicable for the lagoon area groundwater at the North Bronson Site.

- Treat, recover or contain lagoon area groundwater that contains constituents at levels above the established site-specific groundwater cleanup criteria such that the applicable water quality criteria will be met within and at the boundary of the mixing zone.
- Prevent exposure to lagoon area groundwater.

C. Western Lagoons/County Drain #30 Surface Water

As stated above, County Drain #30 is designated as a mixing zone. Thus, the applicable surface water standards for County Drain #30 are based on meeting acute water quality criteria within the mixing zone and chronic water quality criteria at the boundary of the mixing zone. The standing water within several of the Western Lagoons is likely a result of groundwater inflow (i.e., the groundwater table being higher than the bottom of the lagoons). Based on the assumption that the lagoons will be filled in and/or regraded as part of the remedial action for this site, and thus will no longer contain standing water, surface water quality criteria is not applicable for the standing water currently present in the Western Lagoons.

Recommended Surface Water Criteria Based on ARARs

The following surface water criteria apply:

- Site-specific acute water quality criteria within the mixing zone and chronic water quality criteria at the boundary of the mixing zone.

Once the appropriate surface water criteria are established, the County Drain #30 surface water analytical data obtained during the RI will need to be compared against the surface water criteria to determine the degree to which, if any, surface water controls will need to be implemented to meet the following revised RAOs.

Recommended Revised RAO for County Drain #30 Surface Water

Based on the surface water criteria listed above, the following recommended revised RAO is applicable for the surface water in County Drain #30 at the North Bronson Site.

- Control discharges to County Drain #30 to meet the site-specific acute water quality criteria within the mixing zone and chronic water quality criteria at the boundary of the mixing zone.

D. County Drain #30 Sediments

The appropriate RAOs for County Drain #30 sediments are based on exposure scenarios associated with the current and future use of the drain and the protection of water quality in the drain.

Recommended County Drain #30 Sediment Cleanup Criteria Based on ARARs

The following cleanup criteria apply assuming a site-specific risk-based cleanup for the North Bronson Site.

- Site-specific risk-based direct contact criteria determined from a site-specific risk assessment.
- Site-specific sediment criteria that is protective of surface water quality in the drain. Because the drain is designated as a mixing zone, the appropriate sediment criteria that are protective of surface water quality would be based on meeting the site-specific acute water quality criteria within the mixing zone and chronic water quality criteria at the boundary of the mixing zone.

Default County Drain #30 Sediment Cleanup Criteria Based on ARARs

The following cleanup criteria shall apply in the absence of site-specific risk-based criteria for the North Bronson site.

- Generic industrial direct contact criteria for soil as listed in MDEQ Operational Memorandum #14 (MDEQ 1995).
- Sediment criteria that is protective of surface water based on using 20 times the appropriate surface water criterion, 20 times the generic GSI value, leachate test results, or fate and transport modeling in accordance with MDEQ Operational Memorandum #14 (MDEQ 1995), as applicable.

Once the site-specific risk-based cleanup objectives are established, the County Drain #30 sediment analytical data obtained during the RI will need to be compared against the cleanup objectives to determine the degree to which, if any, the County Drain #30 sediments will need to be remediated to meet the following revised RAOs. A similar comparison to the generic industrial cleanup criteria would need to be made in the absence of site-specific risk based criteria for the North Bronson Site.

Recommended Revised RAOs for County Drain #30 Sediments

Based on the cleanup criteria listed above, the following recommended revised RAOs are applicable for the County Drain #30 sediments at the North Bronson site.

- Remove, treat, contain or otherwise limit exposure to County Drain #30 sediments that contain constituents at levels above the established site-specific risk-based direct contact criteria or the generic industrial direct contact criteria, depending on which criteria is utilized for this site.
- Remove, treat or contain County Drain #30 sediments that contain constituents at levels above the site-specific sediment criteria that is protective of surface water, or 20 times the surface water criteria or GSI values,, as applicable.
- Prevent exposure to County Drain #30 sediments.

REFERENCES

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MDNR (Michigan Department of Natural Resources). 1995. Operational Memorandum #14, Revision 2: Remedial Action Plans Using Generic Industrial or Generic Commercial Cleanup Criteria and Other Requirements. Environmental Response Division. June 6, 1995.

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ASSESSMENT OF POTENTIAL SURFACE
WATER IMPACTS ASSOCIATED WITH
VENTED GROUNDWATER

SUPPLEMENT TO THE FEASIBILITY STUDY
FOR THE
NORTH BRONSON INDUSTRIAL AREA SITE
BRONSON, MICHIGAN

March 14, 1996

On behalf of the North Bronson Industrial Site Potentially Responsible Party Group (PRP Group), Geraghty & Miller, Inc. submits this assessment of potential surface water impacts associated with groundwater that vents into County Drain #30 (CD #30) along the Eastern and Western Lagoon areas at the North Bronson Industrial Area Site in Bronson, Michigan. The purpose of this assessment is to determine the extent, if any, the natural venting of groundwater into CD #30 along the Eastern and Western Lagoon areas adversely impacts surface water quality in CD #30 as well as in Swan Creek, which is the downstream discharge point of CD #30. Because the groundwater that may be influenced by the Eastern and Western Lagoons naturally vents into CD #30, its effect on surface water quality must be considered to determine whether groundwater remediation in these areas is necessary.

The Final Feasibility Study (FS) Report (Montgomery Watson 1995) prepared for the North Bronson Site did not address natural groundwater venting to CD #30 as a potentially viable remedial alternative for groundwater in the areas of the Eastern and Western Lagoons. However, as stated in Section 20120a(15) of the Amendments to Part 201 of the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451, groundwater venting to surface water is an acceptable remedial action for groundwater under certain circumstances. Section 20120a(15) further allows for the use of a mixing zone in quantifying the impact of groundwater venting to surface water in accordance with Rule 323.1082 (Mixing Zones). This provision is directly applicable to the North Bronson Site because the Surface Water Quality Division (SWQD) of the Michigan Department of Environmental Quality (MDEQ) has designated CD #30 and one-quarter of the design flow for Swan Creek as a mixing zone.

The MDEQ, in cooperation with the U.S. Environmental Protection Agency (USEPA), is currently revising and/or amending the Final FS Report to incorporate the Part 201 Amendments as an applicable or relevant and appropriate requirement (ARAR) for the North Bronson Site. Consistent with the incorporation of the 201 Amendments as an ARAR for the North Bronson Site, the PRP Group recommends that the MDEQ consider groundwater venting into CD #30 as a viable remedial action for groundwater in the Eastern and Western Lagoon areas at the North Bronson Site. As reflected by the results of the surface water quality assessment presented below, venting of the groundwater to CD #30 likely does not adversely impact surface water quality within CD #30 and Swan Creek.

To assess potential surface water impacts, predicted constituent concentrations were developed for the groundwater that vents into CD #30 and also for the combined flow at the boundary of the mixing zone. These predicted concentrations were then compared against the applicable acute and chronic water quality criteria to determine if these criteria are being exceeded. The results of this assessment are presented in the following sections:

- Description of County Drain #30 Mixing Zone System
- Characterization of Vented Groundwater
- Applicable Surface Water Quality Criteria
- Constituent Loading Into the Mixing Zone
- Predicted Concentrations Within and at the Boundary of the Mixing Zone
- Summary of Potential Surface Water Quality Impacts

Description of County Drain #30 Mixing Zone System

As stated above, the SWQD of the MDEQ has designated CD #30 and one-quarter of the design flow for Swan Creek as a mixing zone (pers. comm. with Sandra Kosek, SWQD of MDEQ). As described in the Remedial Investigation (RI) Report (Warzyn 1993), CD #30 is a drainage ditch that originates approximately one-half mile northeast of the Eastern Lagoons. The drain flows from east to west and eventually discharges to Swan Creek approximately 1.5 miles northwest of the Western Lagoons (Figure 2-1 of the RI Report). The channel of CD #30 ranges from approximately 6 to 8 feet wide and 3 to 6 feet deep. At the time of the RI, the water depth and flow conditions in CD #30 varied from 1 to 2 inches of stagnant water along the eastern portion of the drain and 8 to 10 inches of water and surface flow rates of approximately 1 to 2 feet per second along the western portion of the drain (Warzyn 1993).

Based on the RI Report and information obtained from the SWQD of the MDEQ, there are four permitted point discharges into CD #30: the City of Bronson Publicly Owned Treatment Works (POTW), Bronson Plating Company, Douglas Auto Tech, and Assembly Service. There are also several non-regulated point discharges into CD #30, including two agricultural field drainage outfalls and a City of Bronson storm sewer outfall. In addition to the various point discharges, groundwater from the shallow unconfined aquifer discharges (i.e., vents) into CD #30 from both the north and south sides of the drain (Section 1.2.1.5 and Figure 1-4 of the FS Report).

To estimate constituent concentrations at the boundary of the mixing zone, flow rates were obtained or estimated for the following components of the mixing zone system: 25% of the design flow for Swan Creek, low flow from the Bronson POTW, groundwater flux from the Eastern Lagoon area into CD #30, and groundwater flux from the Western Lagoon area into CD #30. The design flow for Swan Creek at the confluence point with CD #30 is 1,616 gallons per minute (gpm) (pers. comm. with Sandra Kosek, SWQD of MDEQ). As stated in Rule 323.1082, only 25% of the design flow can be used in determining effluent limitations. The low flow rate for the Bronson POTW discharge is approximately 125 gpm (pers. comm. with Chuck Buckley of the Bronson POTW). The flow rate for the Bronson POTW discharge normally averages approximately 200 gpm, but the discharge flow rate occasionally drops to as low as 125 gpm during dry weather, summertime conditions. The low flow rate condition for the Bronson POTW discharge, rather than the average flow rate condition, has been selected for the mixing zone calculations to ensure a conservative prediction of resultant constituent concentrations at the boundary of the mixing zone. The groundwater flux into CD #30 along the Eastern and Western Lagoon areas has been estimated based on the hydrogeologic data collected during the RI (refer to Attachment A for a calculation brief entitled "Calculation of Groundwater Flux Into County Drain #30"). Note that groundwater flux from the other areas along CD #30 cannot be calculated because hydrogeologic information specific to these other areas is not available. Flow rate data were not obtained for the other point source flow components because they vary over time and may potentially cease at some point in the future due to temporary or long-term modifications in the operations at the respective industrial facilities. The flow components that comprise the CD #30 mixing zone are listed below.

CD #30 Mixing Zone Flow Components	Estimated Flow Rate (gpm)
25% of design flow for Swan Creek	404
Low flow for Bronson POTW discharge	125
Groundwater flux from Eastern Lagoon area	4.4
Groundwater flux from Western Lagoon area	7.7
Groundwater flux from other areas along CD #30	unknown
Bronson Plating discharge	varies
Douglas Auto Tech discharge	varies
Assembly Service discharge	varies
Agricultural drainage outfall #1	varies/intermittent
Agricultural drainage outfall #2	varies/intermittent
Bronson storm sewer outfall	varies/intermittent

Characterization of Vented Groundwater

The chemical composition of the groundwater that vents into CD #30 from the Eastern and Western Lagoon areas can be estimated based on the groundwater data collected during the RI. Tables 5-6 and 5-7 of the RI Report list the groundwater analytical results obtained during the RI for the chemical constituents of concern identified for both the Eastern Lagoon area groundwater and the Western Lagoon area groundwater. This data is summarized on the attached Tables 1 and 2 for the Eastern and Western Lagoon areas, respectively. These summary tables present the number of samples, number of detections, average concentrations, and maximum detected concentrations for each constituent of concern based on the sampling of groundwater monitoring wells that encompass the respective areas of the Eastern Lagoons and Western Lagoons. Specific information on the distribution of constituents of concern within the Eastern and Western Lagoon areas is presented in the RI Report (Warzyn 1993).

The groundwater sampling data can be used to predict approximate constituent concentrations in the groundwater that vents to CD #30, but cannot be considered an accurate characterization of groundwater composition at the groundwater/surface water interface. This is because the groundwater monitoring data only reflects groundwater quality at the specific locations and depth at which the various wells are positioned. None of the existing monitoring wells are positioned immediately adjacent to the groundwater/surface water interface along CD #30, and a number of the wells used to established groundwater quality in the respective lagoon areas are positioned several hundred feet upgradient of CD #30. Due to attenuation and dilution, the concentrations of the constituents of concern, especially the trace metals, will likely be lower at the groundwater/surface water interface than the concentrations measured in the various monitoring wells. To better predict the constituent concentrations at the groundwater/surface water interface, additional monitoring wells immediately adjacent to CD #30 could be installed and sampled and/or fate and transport modeling could be conducted.

Applicable Surface Water Quality Criteria

Both the federal and state water quality criteria for the constituents of concern in the vented groundwater from the lagoon areas are listed in each of the attached tables (Tables 1, 2, and 3). Note that the Michigan acute and chronic water quality criteria listed on the attached tables reflect the Rule 57(2) guideline levels that were issued by the SWQD of the MDEQ on January 31, 1996. The acute and chronic water quality criterion for a number of heavy metals that are included as constituents of concern are dependent on the hardness level within the surface water. For determining hardness-dependent chronic criteria, which is applicable at the edge of the mixing zone, a hardness value of 345 milligrams per liter (mg/L) (as calcium carbonate, $CaCO_3$) for Swan Creek was used based on the average hardness value of the two surface water samples (SW-9 and SW-10) collected from Swan Creek during the remedial investigation. For determining hardness-dependent acute criteria, which is applicable within the mixing zone, a hardness value of 370 mg/L (as $CaCO_3$) for CD #30 was used based on the average hardness value of the seven surface water samples (SW-2, SW-3, SW-4, SW-5, SW-6, SW-7, and SW-8) collected from CD #30 during the remedial investigation near the Eastern and Western Lagoon areas.

Constituent Loading Into the Mixing Zone

The various flow components of the CD #30 mixing zone were assessed to determine which flow components contribute to the overall mass loading of the constituents of concern into the mixing zone. The results of the 1995 Waste Characterization Study for the Bronson POTW were reviewed to establish representative constituent concentrations in the effluent from the Bronson POTW. Based on the results of the characterization study, only three of the constituents of concern in the vented groundwater from the lagoon areas are also present in the effluent from the Bronson POTW. These constituents and their respective average concentrations in the Bronson POTW effluent are: copper (13.2 micrograms per liter [ug/L]), nickel (14.0 ug/L), and zinc (46.7 ug/L). It was assumed that the background flow from Swan Creek (i.e., 25 percent of the design flow for Swan Creek) does not contain any of the constituents of concern at levels above detection, and thus does not contribute to the mass loading of constituents into the mixing zone. This assumption is consistent with the approach followed by the SWQD of the MDEQ in assuming zero background concentrations in Swan Creek in their previous determinations of allowable constituent loadings (i.e., permitted discharge limits) from the various permitted point discharges that contribute to the CD #30 mixing zone.

As stated previously, the other three permitted point discharges to CD #30 (Bronson Plating, Assembly Service, and Douglas Auto Tech) are assumed to be zero flow contributors in this mixing zone assessment, and thus are not accounted for in determining concentrations at the edge of the mixing zone. The reason for this is because there are no assurances that these discharges will continue to occur over the period of time in which constituents may be released into CD #30 via groundwater venting from the lagoon areas. Omitting these three additional point discharges in the mixing zone calculations likely leads to more conservative predictions of the concentrations at the boundary of the mixing zone. This is due to the fact that the additional dilution of certain constituents that is likely being realized based on the flow from these three additional point discharges is not being considered in this analysis. For example, the Assembly Service point discharge only consists of non-contact cooling water and thus does not contribute to the mass loading of constituents of concern into the mixing zone. In addition, the rather sizable flow from Bronson Plating (on the order of 100 gpm) generally contains trace amounts of trivalent chromium and nickel, at levels below the applicable discharge standards, but does not contain any of the other constituents of concern that may be present in the groundwater that is vented from the Eastern and Western Lagoon areas. If the flow contribution from these additional point discharges were included in this mixing zone assessment, the predicted concentrations at the boundary of the mixing zone would likely be lower.

The predicted constituent loading rates associated with the vented groundwater from the Eastern and Western Lagoons areas are based on the estimated groundwater flux into the drain (4.4 gpm from the Eastern Lagoon area and 7.7 gpm from the Western Lagoon area) and the average constituent concentrations determined from the groundwater monitoring data that characterize groundwater quality in the respective lagoon areas. The estimated flow rates and constituent concentrations for each of the flow components considered in this mixing zone assessment are listed on Table 3.

The estimated concentration for a particular constituent multiplied by the flow rate equates to the mass loading rate of that constituent associated with a particular flow component. The estimated concentration of a particular constituent at the boundary of the mixing zone can then be calculated based on a mass balance approach as described below.

$$C_{boundary} = [(C_{POTW} \times Q_{POTW}) + (C_{WL} \times Q_{WL}) + (C_{EL} \times Q_{EL})]/[(0.25 \times Q_{SWAN}) + Q_{WL} + Q_{EL}]$$

Where:

$C_{boundary}$	=	Concentration of a constituent at mixing zone boundary
C_{POTW}	=	Concentration of constituent in Bronson POTW effluent
Q_{POTW}	=	Low flow effluent discharge rate from Bronson POTW

C_{WL}	=	Concentration of constituent in vented groundwater from Western Lagoon area
Q_{WL}	=	Groundwater venting rate into CD #30 from Western Lagoon area
C_{EL}	=	Concentration of constituent in vented groundwater from Eastern Lagoon area
Q_{EL}	=	Groundwater venting rate into CD #30 from Eastern Lagoon area
Q_{SWAN}	=	Design flow for Swan Creek

Predicted Concentrations Within and at the Boundary of the Mixing Zone

As specified in Rule 323.1082, the acute water quality criteria shall not be exceeded within a mixing zone at any point inhabitable by aquatic organisms. Consistent with the requirements specified in Rule 323.1090, the chronic water quality criteria shall not be exceeded outside the boundaries of a defined mixing zone. Based on these requirements, it is important to assess predicted concentrations both within and at the boundary of the mixing zone.

As stated previously, the concentrations of the constituents of concern at the groundwater/surface water interface along CD #30 cannot be accurately predicted based on the available groundwater quality data for the respective lagoon areas. The available groundwater monitoring data only reflects groundwater quality at the specific locations of the monitoring wells, none of which are positioned immediately adjacent to the groundwater/surface water interface along CD #30. As indicated above, the concentrations of the constituents of concern, especially the trace metals, will likely be lower at the groundwater/surface water interface than the concentrations measured in the various monitoring wells due to effects of attenuation and dilution. However, it is still useful to compare available groundwater quality data against the applicable acute water quality criteria to make a reasonable assessment as to whether the vented groundwater from the respective lagoon areas is causing adverse impacts to surface water quality at or near the groundwater/surface water interface.

Tables 1 and 2 list the average and maximum concentrations of the constituents of concern detected in groundwater for the Eastern and Western Lagoon areas, respectively, along with the applicable federal and state surface water quality criteria. As shown on Table 1, the average concentrations for the constituents of concern measured in the Eastern Lagoon area groundwater monitoring wells are all less than the associated acute water quality criteria established by the State of Michigan. Only two constituents present in the Eastern Lagoon area groundwater monitoring wells, cadmium and cyanide, have maximum detected concentrations that exceed their acute water quality criteria established by the State of Michigan.

As shown on Table 2, the average and maximum concentrations for the constituents of concern measured in the Western Lagoon area groundwater monitoring wells are all less than the associated acute water quality criteria established by the State of Michigan, with the exception of zinc and cyanide. Both the average and maximum concentrations for zinc and cyanide measured in the Western Lagoon area groundwater monitoring wells exceed the acute water quality criteria for these constituents established by the State of Michigan. It is important to note, however, that there are significant inconsistencies in the analytical results for both zinc and cyanide associated with the groundwater data for the Western Lagoon area. For example, cyanide was detected in Monitoring Well MW-7S at a concentration of 2,960 μg/L in September 1989 (the first sampling event during the RI). Monitoring Well MW-7S was resampled in December 1991 during the second sampling event of the RI, and cyanide was found at a concentration of 250 μg/L. The highest detected concentration of cyanide in the other wells comprising the Western Lagoon area well network was 45.7 μg/L at Monitoring Well MW-5 in September 1989. Similar inconsistencies involving the analytical results reported for zinc are also evident. For example, zinc concentrations in Monitoring Well MW-4 (one of the pre-RI wells) were reported as 8,800 μg/L in September 1989 and 847 μg/L in December 1991. Yet in Monitoring Wells MW-8S and MW-8D, which were installed during the RI immediately adjacent to Monitoring Well MW-4, the highest reported concentration of zinc was 102 μg/L (Monitoring Well MW-8D in September 1989). Based on these significant inconsistencies, all of the groundwater data for zinc and cyanide in the Western Lagoon area may not be reliable.

Even with these few reported constituent concentrations in excess of the applicable acute water quality criteria, the available groundwater data indicate that the groundwater venting from the Eastern and Western lagoon areas is likely not causing any adverse impacts to surface water quality within CD #30. Accounting for natural attenuation and dilution, which is typically very significant for heavy metals, it is unlikely that the groundwater that vents into CD #30 contains constituents of concern at levels above the applicable acute water quality criteria at the groundwater/surface water interface.

In addition to assessing predicted concentrations at the groundwater/surface water interface against the acute water quality criteria, the concentrations at the boundary of the mixing zone also have to be predicted and compared against the applicable chronic water quality criteria. Using the mass balance approach described above, estimated concentrations at the boundary of the mixing zone were calculated for the various constituents of concern. The mass balance input parameters and predicted concentrations at the boundary of the mixing zone are listed in Table 3. As shown on Table 3, the predicted constituent concentrations at the boundary of the mixing zone are all less than the associated federal and state chronic water quality criteria. Note that the actual concentrations at the boundary of the mixing zone are likely less than the predicted concentrations because of the dilution effect caused by the other point source discharges into CD #30 that were not accounted for in this analysis. Because the predicted concentrations at the boundary of the mixing zone are less than the applicable chronic water quality criteria, the natural venting of groundwater from the lagoon areas into CD #30 is not causing any adverse impacts to surface water quality in Swan Creek.

Summary of Potential Surface Water Quality Impacts

As indicated by the results of this assessment, it is unlikely that the venting of groundwater from the Eastern and Western Lagoon areas into CD #30 is causing adverse impacts to surface water quality within CD #30 and Swan Creek. Although the constituent concentrations at the groundwater/surface water interface cannot be accurately predicted based on the existing groundwater data, it is unlikely that the groundwater that vents into CD #30 contains constituents of concern at levels above the applicable acute water quality criteria. Based on the available groundwater data, there have been only a few groundwater samples that were reported to have constituent concentrations higher than the associated acute water quality criteria. Although the acute water quality criteria were exceeded in certain monitoring wells within the respective lagoon areas, it can be reasonably assumed that, due to attenuation and dilution, the constituent concentrations at the groundwater/surface water interface are less than the applicable acute water quality criteria. This assumption is supported by the fact that the average concentrations for the individual constituents of concern determined from the monitoring well data are all less than their respective acute criteria, with the exception of zinc and cyanide in the Western Lagoon area. However, as discussed previously, there are significant inconsistencies in the groundwater data for zinc and cyanide that strongly indicate that the data may not be reliable. Based on the results of this assessment, it is reasonable to assume that the vented groundwater from the Eastern and Western Lagoon areas meets the acute water quality criteria within the mixing zone as required under Rule 323.1082.

Based on a conservative assessment, the predicted constituent concentrations at the boundary of the mixing zone are all less than the applicable chronic water quality criteria. Thus, the vented groundwater from the Eastern and Western Lagoon areas is not causing any adverse impacts to surface water quality in Swan Creek and, thus, meets applicable water quality standards as required under Rule 323.1090.

It is thus concluded from this assessment that remediation and/or control of groundwater in the Eastern and Western Lagoon areas is not necessary to ensure the continued protection of surface water quality in CD #30 and Swan Creek.

REFERENCES

Environmental Standards, Inc. 1995. Conceptual Model For Development of Remedial Action Objectives For The North Bronson Industrial Area Superfund Site. December 1995.

MDNR (Michigan Department of Natural Resources). 1995. Operational Memorandum #14, Revision 2: Remedial Action Plans Using Generic Industrial or Generic Commercial Cleanup Criteria and Other Requirements. Environmental Response Division. June 6, 1995.

Montgomery Watson, Inc. 1995. Final Feasibility Study, North Bronson Industrial Area.

Warzyn, Inc. 1993. Remedial Investigation, North Bronson Industrial Area.

Table 1. Comparison of Groundwater Quality Data with Available Surface Water Quality Criteria, Eastern Lagoon Area, North Bronson Industrial Area, North Bronson, Michigan.

Constituent	Number of Detections[a]	Number of Samples[a]	Average Concentration[b]	Max. Detected Value	Federal Surface Water Criteria Fresh Water Acute	Federal Surface Water Criteria Fresh Water Chronic	Michigan Surface Water Criteria Acute	Michigan Surface Water Criteria Chronic
VOCS(μg/l)								
Vinyl Chloride	1	20	5.0	5.00	--	--	--	3.1
1,2-Dichloroethene (total)	12	20	17.9	120.00	11,600	--	--	300[e]
Trichloroethene	16	20	74.4	400.00	45,000	21,900	4,240	94
INORGANICS (μg/L)								
Arsenic	6	20	2.3	6.60	360	190	701	50
Cadmium	5	20	35.3	301.00	17.2[c]	3.0[d]	46.7[c]	0.97[d]
Chromium III	2	20	5	28.00	5070.3[c]	570.7[d]	3062.7[c]	114.2[d]
Copper	6	20	5.7	18.90	60.8[c]	34.1[d]	140.2[c]	33.0[d]
Nickel	13	20	119.4	1,100.00	4289.9[c]	449.5[d]	3653.4[c]	103.9[d]
Selenium	1	20	0.8	2.40	20	5	220	5
Zinc	12	20	42.1	132.00	354.6[c]	302.7[d]	672.7[c]	143.1[d]
Cyanide	8	20	41.6	531.00	22.0	5.2	47	5.2

[a] Number of detections and number of samples based on the results of two rounds of groundwater sampling during the remedial investigation from the following well network, encompassing the Eastern Lagoon area: MW12S, MW12D, MW13S, MW13D, MW15S, MW15D, MW16S, MW16D, MW17S, MW17D, and MW18.

[b] Average concentrations were calculated using reported concentrations (positive detections) and one-half the method detection limit for each non-detect analytical result (average concentrations are thus likely over estimated).

[c] Hardness-dependent criterion. Hardness value of 370 mg/L (as $CaCO_3$) for County Drain #30 was used, based on the average hardness calculated for the following surface water samples collected during the remedial investigation from County Drain #30 near the Eastern and Western Lagoon Areas: SW-2, SW-3, SW-4, SW-5, SW-6, SW-7, and SW-8.

[d] Hardness-dependent criterion. Hardness value of 345 mg/L (as $CaCO_3$) for Swan Creek was used, based on the average hardness value calculated for the two surface water samples (SW-9 and SW-10) collected from Swan Creek during the remedial investigation.

[e] Criterion is for trans-1,2-dichloroethene. No criterion available for cis-1,2-dichloroethene.

-- No criterion available.

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Table 2. Comparison of Groundwater Quality Data with Available Surface Water Quality Criteria, Western Lagoon Area, North Bronson Industrial Area, North Bronson, Michigan.

Constituent	Number of Detections[a]	Number of Samples[a]	Average Concentration[b]	Max. Detected Value	Federal Surface Water Criteria Fresh Water Acute	Federal Surface Water Criteria Fresh Water Chronic	Michigan Surface Water Criteria Acute	Michigan Surface Water Criteria Chronic
VOCS(µg/l)								
Vinyl Chloride	9	25	22.6	100	--	--	--	3.1
1,2-Dichloroethene (total)	14	25	123.5	960	11,600	--	--	300[e]
Trichloroethene	18	25	72.0	450	45,000	21,900	4,240	94
INORGANICS (µg/L)								
Arsenic	19	25	4.4	9.9	360	190	701	50
Cadmium	9	25	6	36.3	17.2[c]	3.0[d]	46.7[c]	0.97[d]
Lead	3	25	3.3	26	432.9[c]	15.4[d]	1448.7[c]	17.07[d]
Nickel	17	25	139.4	627	4,289.9[c]	449.5[d]	3653.4[c]	103.9[d]
Zinc	20	25	970.0	8,800	354.6[c]	302.7[d]	672.7[c]	143.1[d]
Cyanide	6	25	135.3	2,960	22.0	5.2	47	5.2

a Number of detections and number of samples based on the results of two rounds of groundwater sampling during the remedial investigation from the following well network, encompassing the Western Lagoon area: MW1, MW2, MW3, MW4, MW5, MW6, MW6S, MW7S, MW8S, MW8D, MW9S, MW26, MW27, and MW28.

b Average concentrations were calculated using reported concentrations (positive detections) and one-half the method detection limit for each non-detect analytical result (average concentrations are thus likely over estimated).

c Hardness-dependent criterion. Hardness value of 370 mg/L (as $CaCO_3$) for County Drain #30 was used, based on the average hardness calculated for the following surface water samples collected during the remedial investigation from County Drain #30 near the Eastern and Western Lagoon Lagoon areas: SW-2, SW-3, SW-4, SW-5, SW-6, SW-7, and SW-8.

d Hardness-dependent criterion. Hardness value of 345 mg/L (as $CaCO_3$) for Swan Creek was used, based on the average hardness value calculated for the two surface water samples (SW-9 and SW-10) collected from Swan Creek during the remedial investigation.

e Criterion is for trans-1,2-dichloroethene. No criterion available for cis-1,2-dichloroethene.

-- No criterion available.

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Table 3. Edge of Mixing Zone Constituent Concentrations and Comparison with Applicable Surface Water Quality Criteria, North Bronson Industrial Area, North Bronson, Michigan.

	Mixing Zone Flow Components							
	Bronson POTW		Bronson Plating		Assembly Service		Douglas Auto Tech	
Constituent	Flow	Concentration	Flow	Concentration	Flow	Concentration	Flow	Concentration
VOCS(µg/l)								
Vinyl Chloride	125	0	0	0	0	0	0	0
1,2-Dichloroethene (total)	125	0	0	0	0	0	0	0
Trichloroethene	125	0	0	0	0	0	0	0
INORGANICS (µg/L)								
Arsenic	125	0	0	0	0	0	0	0
Cadmium	125	0	0	0	0	0	0	0
Chromium III	125	0	0	0	0	0	0	0
Copper	125	13.2	0	0	0	0	0	0
Lead	125	0	0	0	0	0	0	0
Nickel	125	14	0	0	0	0	0	0
Selenium	125	0	0	0	0	0	0	0
Zinc	125	46.7	0	0	0	0	0	0
Cyanide	125	0	0	0	0	0	0	0

Flows are expressed in units of gallons per minute (gpm)

Concentrations are expressed in units of micrograms per liter (ug/L)

[a]Mixing zone flow component of Swan Creek is 25% of the 1,616 gpm design flow of Swan Creek. Total flow at mixing zone is the sum of the six flow components into County Dain #30 and 25% of the design flow of Swan Creek. Per MDEQ, Surface Water Quality Division, the the design flow for Swan Creek is 3.6 cubic feet per second (1616 gpm).

[b]Hardness-dependent criterion. Hardness value of 345 mg/L (as $CaCO_3$) for Swan Creek was used, based on the average hardness value calculated for the two surface water samples (SW-9 and SW-10) collected from Swan Creek during the remedial investigation.

-- No criterion available.

NA Not applicable (acute criteria does not apply at edge of mixing zone).

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Table 3. Edge of Mixing Zone Constituent Concentrations and Comparison with Applicable Surface Water Quality Criteria, North Bronson Industrial Area, North Bronson, Michigan.

	Mixing Zone Flow Components					
	Eastern Lagoon Groundwater Venting		Western Lagoon Groundwater Venting		Swan Creek	
Constituent	Flow	Concentration	Flow	Concentration	Flow[a]	Concentration
VOCS(µg/l)						
Vinyl Chloride	4.4	5.0	7.7	22.6	404	0
1,2-Dichloroethene (total)	4.4	17.9	7.7	123.5	404	0
Trichloroethene	4.4	74.4	7.7	72.0	404	0
INORGANICS (µg/L)						
Arsenic	4.4	2.3	7.7	4.4	404	0
Cadmium	4.4	35.3	7.7	6.0	404	0
Chromium III	4.4	5.0	7.7	0.0	404	0
Copper	4.4	5.7	7.7	0.0	404	0
Lead	4.4	0.0	7.7	3.3	404	0
Nickel	4.4	119.4	7.7	139.4	404	0
Selenium	4.4	0.8	7.7	0.0	404	0
Zinc	4.4	42.1	7.7	970.0	404	0
Cyanide	4.4	41.6	7.7	135.3	404	0

Flows are expressed in units of gallons per minute (gpm)

Concentrations are expressed in units of micrograms per liter (ug/L)

[a]Mixing zone flow component of Swan Creek is 25% of the 1,616 gpm design flow of Swan Creek. Total flow at mixing zone is the sum of the six flow components into County Dain #30 and 25% of the design flow of Swan Creek. Per MDEQ, Surface Water Quality Division, the the design flow for Swan Creek is 3.6 cubic feet per second (1616 gpm).

[b]Hardness-dependent criterion. Hardness value of 345 mg/L (as $CaCO_3$) for Swan Creek was used, based on the average hardness value calculated for the two surface water samples (SW-9 and SW-10) collected from Swan Creek during the remedial investigation.

-- No criterion available.

NA Not applicable (acute criteria does not apply at edge of mixing zone).

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Table 3. Edge of Mixing Zone Constituent Concentrations and Comparison with Applicable Surface Water Quality Criteria, North Bronson Industrial Area, North Bronson, Michigan.

Constituent	Total Flow at Edge of Mixing Zone	Estimated Constituent Concentration at Edge of Mixing Zone	Federal Surface Water Criteria Fresh Water Acute	Federal Surface Water Criteria Fresh Water Chronic	Michigan Surface Water Criteria Acute	Michigan Surface Water Criteria Chronic
VOCS(μg/l)						
Vinyl Chloride	541.10	0.36	NA	--	NA	3.1
1,2-Dichloroethene (total)	541.10	1.90	NA	--	NA	300
Trichloroethene	541.10	1.63	NA	21,900	NA	94
INORGANICS (μg/L)						
Arsenic	541.10	0.08	NA	190	NA	50
Cadmium	541.10	0.37	NA	3.0[b]	NA	0.97[b]
Chromium III	541.10	0.04	NA	570.7[b]	NA	114.2[b]
Copper	541.10	3.10	NA	34.1[b]	NA	33.0[b]
Lead	541.10	0.05	NA	15.4[b]	NA	17.07[b]
Nickel	541.10	6.19	NA	449.5[b]	NA	103.9[b]
Selenium	541.10	0.01	NA	35	NA	5
Zinc	541.10	24.93	NA	302.7[b]	NA	143.1[b]
Cyanide	541.10	2.26	NA	5.2	NA	5.2

Flows are expressed in units of gallons per minute (gpm)

Concentrations are expressed in units of micrograms per liter (ug/L)

[a]Mixing zone flow component of Swan Creek is 25% of the 1,616 gpm design flow of Swan Creek. Total flow at mixing zone is the sum of the six flow components into County Dain #30 and 25% of the design flow of Swan Creek. Per MDEQ, Surface Water Quality Division, the the design flow for Swan Creek is 3.6 cubic feet per second (1616 gpm).

[b]Hardness-dependent criterion. Hardness value of 345 mg/L (as $CaCO_3$) for Swan Creek was used, based on the average hardness value calculated for the two surface water samples (SW-9 and SW-10) collected from Swan Creek during the remedial investigation.

-- No criterion available.

NA Not applicable (acute criteria does not apply at edge of mixing zone).

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ATTACHMENT A

CALCULATION OF GROUNDWATER FLUX INTO COUNTY DRAIN #30 NORTH BRONSON INDUSTRIAL AREA SITE BRONSON, MICHIGAN

Objective: Estimate flux of groundwater into County Drain #30 along the areas of the Eastern and Western Lagoons.

Assumption: Assume County Drain #30 hydraulically functions as a fully penetrating drain, although physically it does not penetrate the full depth of the shallow unconfined aquifer (i.e., assume that there is no underflow beneath County Drain #30).

Darcian flow to open channel

Using:	$Q = TiW$	where	Q = discharge to channel T = transmissivity i = gradient W = discharge width
And:	$T = Kb$		K = hydraulic conductivity b = aquifer thickness (near open channel)

From the RI report (Warzyn 1993), geometric mean K for surficial aquifer (p. 4-6) is **1.38×10^{-3} ft/s = K**

From the RI report (Warzyn 1993) Tables 4-2 and 4-3, and Figures 4-4, 4-5, and 4-6, measurements of aquifer thickness (b) in area of County Drain #30 (CD #30) are:

Well	Aquifer Thickness	6/25/92 Depth to Water	b
MW-8D	27 ft	6.30	20.70
MW-13D	26 ft	7.95	18.05
MW-12D	26 ft	8.32	17.68
MW-25	24 ft	7.05	16.95

Average 18.35 ft = b

$T = Kb$
$T = (1.38 \times 10^{-3}$ ft/s) * (18.35 ft)
$T = 2.53E\text{-}2$ ft²/s

Gradient value was selected based on RI report (Warzyn 1993) discussion regarding influence of drain on groundwater flow and thinning of aquifer toward CD #30. Gradient value between wells MW-24 and MW-25 was selected as representative of all flow to drain. From Table 4-4 of the RI report the horizontal gradient between Wells MW-24 and MW-25 is:

$i_T = 9.92 \times 10^{-4}$ ft/ft

The length of CD #30 within the area of study was estimated from Figure 5-3 of the RI report:

w = 3255 ft

$Q = TiW$
$= (2.53E\text{-}2\ ft^2/s)(9.92E\text{-}4)(3255\ ft)(7.48\ gal/ft^3)(60\ s/min)$
Q = 36.6

Q = 36.6/3255 ft = **0.011 GPM/ft²-2 gpm/ft**

This value is for discharge to CD #30 from south side of channel; north side discharge is assumed to be the same.

Estimated flux specific to Eastern and Western Lagoon areas based on assumed width of groundwater potentially influenced by the respective lagoons:

Width of influence of Eastern Lagoons = 400 ft (Figure 2-15 of FS report).

Estimated flux from Eastern Lagoon area = (0.011 GPM/ft²)(400 ft) = 4.4 GPM

Width of influence of Western Lagoons = 700 ft (Figure 2-14 of the FS report).

Estimated flux from Western Lagoon Area = (0.011 GPM/ft)(700 ft) = 7.7 GPM.

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